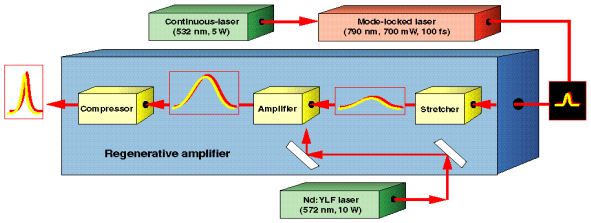
Ultra Short Pulse Laser Surgery

The Ultra Short Pulse Laser (USPL)

Researchers at the Lawrence Livermore National Laboratory are using the Ultra Short Pulse Laser (USPL) as a surgical tool to creates high precision cuts without damaging surrounding tissue. After low energy ultra short pulses are formed in a mode-locked Ti:sapphire laser, the short pulses are amplified in a regenerative amplifier. Here the ultrashort pulses are first "stretched" by separating the pulses into their color elements, amplifying the individual elements and then recombining these in the "compressor" section.



The architecture of our USPL system.

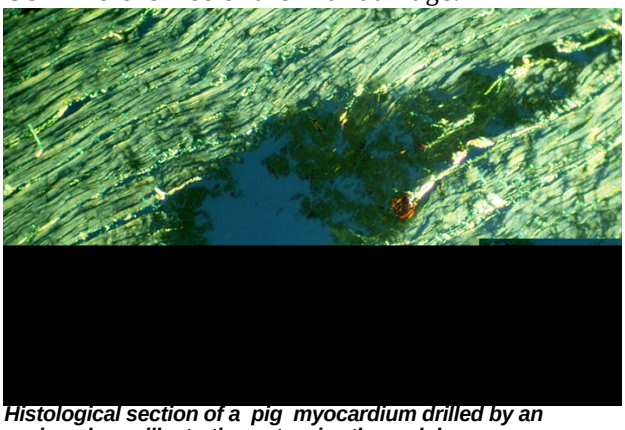
Improvements in the miniaturization of these systems will permit manufacturing of compact, low cost and reliable systems for the medical suite.

Future use of the USPL for medical applications requires a laser sized for the medical suite. In this example, a dentist is removing carious material with a laser delivered through an articulated arm.

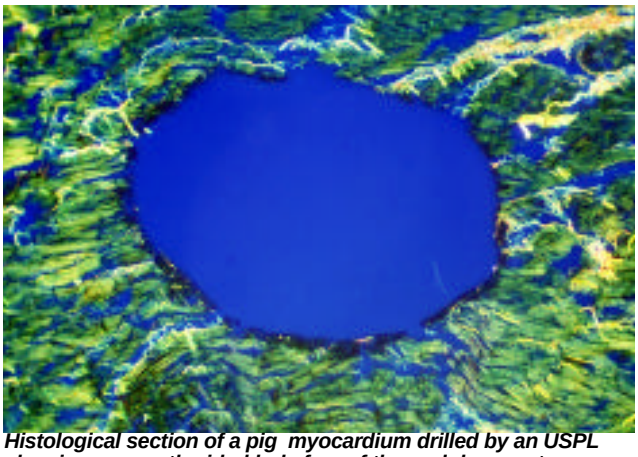
The Ultra Short Pulse Laser (USPL) produces such short duration bursts of laser energy that surface material is removed without any significant transfer of energy to the surrounding areas. For laser pulses less than about 10 ps (1/100th of a billionth of a second), we've found that we can cut without collateral damage to surrounding tissues. By combining newly miniaturized commercial sources of ultra short pulse lasers with our delivery systems and diagnostics, we've created a powerful new surgical tool that creates tiny cuts with amazingly small kerf (>100 um). We can also drill tiny holes (>150 um diameter) all without thermal or mechanical damage to surrounding areas.

Applications

Transmyocardial Revascularization: For diseased hearts where surgical repair of the vascular system is not an option, substantial increase in heart output, and reduction in patient pain has been achieved by producing numerous small diameter holes through the heart muscle (myocardium) into the inner chambers. USPL drilling is believed to be superior to current excimer and CO_2 lasers for TMR because the damage to the tissue surrounding the hole is minimized. In the top micrograph, a histological section of an excimer laser hole in rat aorta shows extensive thermal damage (dark areas) surrounding the hole, whereas in the bottom micrograph, the USPL hole is free of thermal damage.



Histological section of a pig myocardium drilled by an excimer laser, illustrating extensive thermal damage surrounding the hole.



Histological section of a pig myocardium drilled by an USPL showing a smooth-sided hole free of thermal damage to surrounding tissue.